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Agro Morphological Trait and Yield Component Evaluation of Malt Barley (*Hordeum Distichon* L.) Varieties Response to the Rate of Fertilizer in Habro Woreda West Hararghe Zone, Oromia, Ethiopia

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Abstract: ***The study assessed the effects of NPSB Fertilizer Rate on Yield and morphological traits of Malt barley Varieties. The experiment used a Randomized Complete Block Design with three varieties and five levels of fertilizer rates. The effects of NPSB fertilizer rate and varieties were highly significant on all yield components; phenology and morphological traits. The highest number of kernels per spike (29.5), above ground biomass (12.0 tha^{-1}), and straw yield (6.4 tha^{-1}) were obtained from 200kg NPSB ha^{-1} , while highest the thousand grain weights (48.2g) were obtained from 150kg NPSB ha^{-1}. The interaction effects of varieties and fertilizer rates were significant at p<0.05 on grain yield (5653.3) from the Traveller variety at 150 kg NPSB ha^{-1} fertilizer rates. The analysis of variance showed that the interaction effects of varieties and fertilizer rates were significant at p<0.05 on Hectoliter (69.133) from the Traveller variety at 150 kg NPSB ha^{-1} fertilizer rates. Finally, from the above result, it can be concluded that using 150 kg ha^{-1} NPSB fertilizer with Traveller variety can be recommended for malt barley production in the study area.***

Keywords: ***Malt barley, Varieties, Morphological traits, NPSB Fertilizer, Yield***

I. INTRODUCTION

Barley (*Hordeum spps* L.) is the most important cereal crop produced largely in the World and it ranks fourth in production after wheat, maize, and rice [15]. Ethiopia is one of the major producers of barley and the second largest producer in Africa next to Morocco [35]. Barley is preferred over other cereals for its early maturity relieving hunger, grain yield stability, double cropping, and amenability for small rains (*Belg*) growing in Ethiopia [3] and [39]. It is grown in a wide range of environments with altitude ranges of 1500 and 3500 m.a.s.l, but predominantly grown from 2000 to 3500 m.a.s.l.

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However, barley is the fifth most important cereal crop after teff, wheat, maize, and sorghum in area coverage [25]. The total area covered by barley is about 950,742.01 hectares with a total production of 2.378 million tons in the Country [9]. The majority of barley produced in the worldwide is useful for animal feed, preparing malt, and as a sources of starch for alcoholic beverages [8] and [36]. Nowadays, the utilization of barley as malt is increased as compared to other cereals, which contain carbohydrate (67%) and protein (12.8%) as well as the source of sugars (principally maltose), which are fermented into beer. malt barley is becoming a major income source to smallholder farmers in the highland areas of Ethiopia, particularly where the agroecologies are not more productive than other cereal crops [16].

However, in Ethiopia, malt barley productivity is lower than other producing countries such as the United Arab Emirates, Belgium, and the Netherlands. This is due to the combination of genetic, socioeconomic constraints and inappropriate use of integrated technologies and environmental factors like altitude, rainfall, soil types, and pH of the soil [16]. Breweries have been set up in the country, which require large quantities of barley for malt, and in recent years the demand for malting barley has increased significantly in the country [11]. Poor soil fertility, agronomic practice of farming, inappropriate variety selection; Lake use of new technology, mono cropping, poor seedbed preparation; inappropriate seeding date, inappropriate crop protection technology, and application of unbalanced nutrients are among the key limitations of barley production in Ethiopia [6] and [14]. Also, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as nitrogen (86%), phosphorus (99%), sulfur (92%), boron (65%), and zinc (53%) are widespread in Ethiopian soils and similarly in the study area [22] and [31]. The challenge facing malt barley growers is how to use blended fertilizer rates to increase productivity. The information on the application rate of fertilizer NPSB especially for barley was not determined for the study area. Therefore, this study was conducted to investigate the effects of NPSB fertilizers on Agromorphological traits and yield components of malt barley at Habro District, Western Hararghe Zone of Oromia.

II. MATERIALS AND METHODS

A. Description of Experimental Site

The study was conducted at Habro Woreda during the cropping season in 2023. Habro is found in West Hararghe Zone of Oromia Regional State and located at latitude of 7⁰02' 45''to 7⁰31'35''N, longitude of 38⁰47'04'' to 39⁰04'36'' E at 1500 to 3300 meters above sea level (m.a.s.l). This area is characterized as warm temperate with sub-humid to humid agro–climatic condition with silt loam soil type. It receives bi modal mean annual rainfall from March to October, where the highest precipitation occurs in July and August with average annual rainfall is 1050 mm. The annual mean maximum and minimum temperature of 29°C and 23°C Respectively. Wheat, sorghum, Maize, Teff, barley, faba bean, and field pea are the major grown crops in the study area. The study was conducted at Habro Woreda during the cropping season in 2023. Habro is found in West Hararghe Zone of Oromia Regional State and located at a latitude of 7⁰02' 45''to 7⁰31'35''N, longitude of 38⁰47'04'' to 39⁰04'36'' E at 1500 to 3300 meters above sea level (m.a.s.l). This area is characterized as warm temperate with sub-humid to humid agro-climatic conditions with silt loam soil type. It receives bi-modal mean annual rainfall from March to October, where the highest precipitation occurs in July and August with an average annual rainfall is 1050 mm. The annual mean maximum and minimum temperature of 29°C and 23°C Respectively. Wheat, sorghum, Maize, Teff, barley, fava bean, and field pea are the major grown crops in the study area.

B. Experimental Materials

i.Plant Material

Traveler, Ibon 174/03 and Sabini malt barley varieties were used for research experiment. All varieties are adapted to areas located in 2000-2800 meters above sea level and receiving an annual rainfall of 750-1000 mm [30]. 100 kg ha^{-1} NPSB fertilizer rate was applied and recommendation for the study. Traveler, Ibon 174/03, and Sabini malt barley varieties were used for the research experiment. All varieties are adapted to areas located 2000-2800 meters above sea level and receiving an annual rainfall of 750-1000 mm [30]. 100 kg ha-1 NPSB fertilizer rate was applied and recommended for the study.

ii.Treatments and Experimental Design

The treatments have five levels of NPSB fertilizer application rates such as 0 kg ha^{-1}, 50 kg ha^{-1}, 100 kg ha^{-1},150 kg ha^{-1} and 200 kg ha^{-1}. And also 46 kg N ha^{-1} was used uniformly to all the plots. The experiment was laid out as a randomized complete block design (RCBD) and replicated three times. There were fifteen treatment combinations, which were assigned to each plot randomly.

The treatments have five levels of NPSB fertilizer rate applications (0 kg ha-1, 50 kg ha-1, 100 kg ha-1,150 kg ha-1and 200 kg ha-1). Also, 46 kg N ha-1 was used uniformly in all the plots. The experiment was laid out as a randomized complete block design (RCBD) and replicated three times. There were fifteen treatment combinations, which were assigned to each plot randomly.

Table 1: Fertilizer and Treatments Used

Treatment	NPSB (kgha^{-1})	N (kgha^{-1})	P_2o_5 (kgha^{-1})	S (kgha^{-1})	B (kgha^{-1})
1	0.00	46	0	0	0
2	50.00	55.5	18.82	3.47	0.05
3	100.00	64.9	37.65	6.95	0.1
4	150.00	74.35	56.46	10.43	0.15
5	200.00	83.79	75.4	13.9	0.2

C. Experimental Procedure and Crop Management

The land was prepared by tractor to a depth of 25-30cm one time. The plots were leveled manually. Each gross plot was an area of 2m × 3m =6 m^{2}and Spacing between plots and between blocks was 0.5m and 1m, respectively. Treatments were assigned to each plot randomly. The spacing between rows was 20 cm. The one outermost row from each side and 10 cm length from both ends of each row was considered as a border. Thus, the net plot was 8 rows with 2.8m length and 2.8m× 1.60m (4.48m2) area. Seed sowing was done with a drilling method at a depth of 3 cm to ensure adequate emergence saturated with moisture of seed rate 100 kg/ha.

D. Data Collection

i.Yield Components and Yield

The total number of effective tillers (TNET)**:** was determined from the 0.5 m length of two rows from the net plot and converted to per meter square of net plot at physiological maturity by counting the number of tillers. Number of productive tillers**:** was determined by counting all spikes bearing tillers from two rows of 0.5 m length per the net plot at physiological maturity and as converted to per meter square. Number of kernels per spike (NKPS): was calculated as an average of five randomly taken spikes from the net plot area. Spike length (SL)**:** was measured from the bottom of the spike to the tip of the spike excluding the awns from five randomly selected spikes from the net plot. Thousand kernels weight (TKW in g): was determined based on three samples of 1000 kernel weight taken from the grain yield of each net plot by using electronic seed counter and weighed with sensitive balance. Finally, the mean was computed and the weight was adjusted to 12.5% moisture content. Aboveground dry biomass (AGDB in kg ha^{-1}): was determined from plants harvested from the net plot area after sun drying to a constant weight and converted to kg per hectare. Grain yield (GY in kg ha^{-1}): was taken by harvesting and threshing the seed yield from net plot area. The grain weight of each plot was recorded in kg plot^{-1}and converted to kg ha^{-1} . Straw Yield (kg/ha): was obtained as the difference of the total above ground dry biomass and grain yield. Harvest index (HI in % on plot basis): was calculated from ratio of grain yield per plot to total aboveground dry biomass yield per plot multiplied by 100. $HI=\frac{Economic\ yield}{Biological\ yield}\times 100$

Protein Content: Grain protein content was determined by multiplying the N content by the conversion factor of 6.25 according to the standard macro-Kjeldhal procedure [1] and [33].

E. Agronomic Efficiency

The NPSB fertilizer agronomic efficiency was calculated using the procedure described by Cras well and Godwin (1984) as: $AE\left(\frac{Kg}{kg}\right)=\frac{Gf(kg)-Gu\,(kg)}{Na\;(kg)}$

Where; AE for agronomic efficiency, Gf and Gu for grain yield in fertilized and unfertilized plots, respectively and Na for quantity of NPSB fertilizer applied.

F. Statistical Data Analysis

All data collected was subjected to analysis of variance (ANOVA) procedure. Analysis of variance and Least significance test was compared at P<0.05 by using SAS statistics software (ver.9.2, 2008).

G. Economic Analysis

The economic analysis was carried out according to prevailing market prices for inputs at planting and outputs at harvesting [10]. All costs and benefits were calculated on a hectare basis in Birr. Adjusted grain yield (AGY) (kg ha^{-1}): was the average yield adjusted downward by 10% to reflect the difference between the experimental yield and yield of farmers. Gross field benefit (GFB) (ETB ha^{-1}): was computed by multiplying the field/farm gate price that farmers receive for the crop when they sell it as adjusted yield. GFB = AGY × field/farm gate price for the crop.

Total variable cost (TVC) (ETB ha^{-1}): it was the cost of NPSB and labor cost involved in the application of the fertilizer. Net benefit (NB) (ETB ha^{-1}): was calculated by subtracting the total variable costs (TVC) from gross field benefits (GFB) for each treatment. Dominance Analysis: The dominance analysis was carried out by first listing all the treatments in their order of increasing costs that vary (TVC) and their net benefits (NB) are then put aside. Any treatment that has higher TVC but net benefits that are less than or equal to the preceding treatment (with lower TVC but higher net benefits) is the dominated treatment (marked as "D"). The dominance analysis illustrates that to improve farmers' income, it is important to pay attention to net benefits rather than yields because higher yields do not necessarily mean high net benefits. Marginal rate of return (MRR) (%): was calculated by dividing the change in net benefit (ΔNB) by the change in total variable cost (ΔTVC). $\text{MRR} = \frac{\Delta\text{NB}}{\Delta\text{TVC}} \times 100$. Finally, among the non-dominated treatments, the treatment which gives the highest net return and a marginal rate of return greater than the minimum considered acceptable to farmers (100%) was considered for recommendation.

III. RESULTS AND DISCUSSION

A. Yield Components

i.Total Number of Tillering

Analysis of variance showed that the number of tillers was highly significantly (P≤0.001) affected by varieties and NPSB fertilizer rate but their interaction was non-significant. This showed that the variety of Traveller produced the highest total number of tillers per plant (9.7) but the variety of Sabini 174/03 gave the lowest numbers of tillers per plant (8.2). The highest number of tillers was obtained with the highest rates of NPSB fertilizer due to the role of N in accelerating the vegetative growth of plants. Therefore, the number of tillers at the highest rates of NPSB fertilization has a rapid conversion of synthesized carbohydrates into protein and consequently an increase in the number and size of growing cells. This is similar to the application of blended fertilizer that brought a significant difference in tillers [7]. The highest mean number of tillers (11.1) per plant was recorded from 200 NPSB kg and the lowest mean number of total tillers (5.9) per plant from control 0 NPSB kg (Table 2). This is agreed with the report that macro and micronutrients (Nitrogen, Phosphorus with Sulfur and Boron) fertilizers application can increase plant height, spike length, number of tillers, and number of kernels with increasing doses and combination [37].

ii.Effective Tillering

The main effects of NPSB fertilizer rate and varieties were highly significant at (p<0.01) on productive tillers but their interaction effect was non-significant. The result showed that the Traveller variety produced the highest tillers per plant (8.9), while the Eboni variety 174/03 gave the lowest numbers of tillers (6.7) per plant. The difference in effective tiller among the varieties might be the inherent nature of the variety, which would produce a different number of tillers in the given environmental conditions. The varieties that had more numbers of tillers, produced more grain yield ha^{-1}. This result is agreed with the reported increase in the number of effective tillers with nitrogen fertilization [27]. The highest mean number of effective tillers (10.2) per plant was recorded from 200 NPSB kg and the lowest mean number of effective tillers (4.4) per plant was recorded from control 0 NPSB kg and also 150 NPSB kg produced mean number of effective tiller (9.4) and with 100 NPSB kg produced mean number of effective tiller (7.9) per plant (Table 2). The increase in the number of effective tillers produced in response to the increased application rates of NPSB fertilizer may be due to the higher application of NPSB as the roles played by N in enhancing effective tillers by the plant. This result agrees with the findings reported that increasing N rates increased the numbers of effective tillers, where increasing N rate from 23 to 69 kg ha^{-1} increased tiller production by 66.7% [5] and [24].

iii.Number of Kernel Per Spike

The main effects of NPSB fertilizer rate and varieties had a highly significant (p<0.01) on the number of Kernels per spike but their interaction effect was non-significant. The result showed that a variety of Travellers produced the highest number of kernels per spike (28). On the other hand, variety Eboni 174/03 gave the lowest number of kernels per spike (25.8) and Sabini kernel per spike (27.3) per spike (Table 2). The increment of kernel per spike with increasing NPSB fertilizer application rates.

This might be due to nutrient efficiency by crop being enhanced at an optimum level of NPSB since the number of kernels per spike indicates the amount of resource utilized during critical growth periods. This result is in agreement with the report conducted; increased N application (0 to 200 kg ha^{-1}) resulted in significantly higher numbers of grain per spike as compared to the control treatment [34].

The highest mean number of kernel per spike (29.5) were recorded from 150 NPSB kg and the lowest mean number of kernel per spike (23.8) were recorded from control 0 NPSB kg and also 200 NPSB kg produced mean number of kernels per spike (28.7) and statically at par with 100 NPSB kg produced mean number of kernel per spike (27.0) (Table 3). This is lined up with the result reported that a maximum of 53 and minimum of 31 number kernels per spike were obtained from the application of 200 kg NPSB fertilizer ha^{-1} .

iv.Thousand grain weight

The main effects of NPSB fertilizer rate and varieties had a highly significant ($p<0.01$) on thousand-grain weight but their interaction effect was non-significant. The result showed that Traveller produced the highest number of thousand kernel weights (47.6 g), while Eboni 174/03 produced the lowest thousand kernel weights (44.5 g) followed by Varity of Sabini produced (44.9 g) (Table 2). The difference in thousand kernel weight among the varieties might be due to the genetic nature of the crop variation in performance during the grain filling period that gives the highest thousand-grain weight. This is agreed with the result stated that the thousand grain weight is an important yield determining component [32]. The highest mean of thousand kernel weight (48.2 g) was recorded from 150 NPSB kg and the lowest mean of thousand kernel weight (42.7 g) was obtained from control 0 NPSB kg and also 200 NPSB kg produced mean of thousand kernel weight (46.9 g) and statically at par with 100 NPSB kg produced mean of thousand kernel weight (46.1) (Table 2). Thousand grain weights obtained from fertilized plots were significantly higher than unfertilized plots/control. This result is similar to the report conducted that the maximum (43.97 gm) 1000 kernel weight was obtained from the application of 200 kg NPSB fertilizer treatment, Whereas the lowest (28.37) 1000 kernel weight was obtained from the control [29].

Table 2: Effects of NPSB Fertilizer Rate and Variety of Barley on Yield and Morphological Traits

Variety	TNT	TET	KPS	TGW
Sabini	8.2^{b}	7.2^{b}	27.3^{a}	44.9^{b}
Eboni174/03	7.9^{b}	6.7^{b}	25.8^{b}	44.5^{b}
Traveller	9.7^{a}	8.9^{a}	28.1^{a}	47.6^{a}
LSD	0.5	0.7	1.3	1.0
NPSB Rate				
0	5.9^{e}	4.4^{d}	23.8^{c}	42.7^{d}
50	7.3^{d}	6.2^{c}	26.2^{b}	44.5^{c}
100	8.7^{c}	7.9^{b}	27.0^{b}	46.1^{b}
150	10.0^{b}	9.4^{a}	29.5^{a}	48.2^{a}
200	11.1^{a}	10.2^{a}	28.7^{a}	46.9^{ab}
LSD	0.7	0.8	1.7	1.3
CV	8.2	11.5	6.7	3.0

LSD (0.05) =Least Significant Difference at 5% level's CV=Coefficient of Variation; TNT=Total Number of Tiller; TET=Total Effective Tiller; KPS=Kernel per Spike; TGW=Thousand Grain Weight; Means in column followed by the same letters are not significantly different at 5% levels of significance.

v.Grain yield

The main effects of NPSB fertilizer rate and varieties were highly significant ($p<0.01$) on grain yield but their interaction was non-significant. The highest grain yield (5.653t ha^{-1}) was recorded from 150 kg NPSB ha^{-1} from Traveller while the lowest grain yield was recorded from Eboni 174/03 (1.4733t ha^{-1}) with 0 kg NPSB ha^{-1} (Table 3). This might be due to the difference in the genetic makeup of grain yield potential and response to yield constraints of variety [23]. The highest grain yield at the highest NPSB rates resulted from improved root growth, increased uptake of nutrients and better growth due to synergetic effects of the nutrients which enhanced yield components and yield. This result was in agreement with the report indicating significant increases in grain yields with increasing levels of N fertilizer and growth parameters [38]. This is similarly the report stated that the application of blended fertilizer increases, also significantly the grain yields of Teff increased and achieved the highest grain yields (1301 kg ha^{-1}) by application of 200kg ha^{-1} blended fertilizer and indicated that the maximum grain yield of 4.9t ha^{-1} by 200 kg ha^{-1} of fertilizer rate application and the minimum grain yield of 2.24t ha^{-1} obtained from the plots received from unfertilized treatment [21] and [40].

vi.Straw Yield

The main effects of NPSB fertilizer rate and varieties were highly significant ($p<0.01$) on straw yield but their interaction effect was non-significant. The result showed that the Traveller variety produced the highest number of straw yields (5.2 t ha^{-1}), whereas the Eboni 174/03 variety produced the lowest straw yield (4.2 t ha^{-1}) (Table 3). The difference in straw yield among the varieties might be due to, the difference in the genetic make-up of the crop. The analysis of variance showed that the highest mean of straw yield (6.4 t) was recorded from 200 NPSB kg followed by 150 and 100 NPSB fertilizer rates, while the lowest mean of straw yield (2.9t ha^{-1}) was recorded with a control of 0 NPSB kg (Table 5). Significant increase in straw yield in response to the highest rate of NPSB application. This is lineup with the report conducted on the maximum straw yield (12.43 t ha-1) with the application of 60 kg ha-1 phosphorus in the form of DAP [26].

vii.Above Ground Dry Biomass

The main effects of NPSB fertilizer rate and varieties had a highly significant ($p<0.01$) on above-ground dry biomass but their interaction effects were non-significant. The result showed that the Traveller variety produced the highest number of above ground dry biomass (9.8t ha^{-1}), whereas the Eboni 174/03 variety produced the lowest above ground dry biomass (8.0 t ha^{-1}) (Table 3). Above ground dry biomass is the sum of all dry matter produced through physiological and biochemical processes occurring in the plant system. The analysis of variance showed that the main effect of the NPSB rate significantly affected the above ground dry biomass.

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The highest mean of above ground dry biomass (12.0 t ha^{-1}) was recorded from 200 NPSB kg followed by 150 and 100 NPSB fertilizer rates, whereas the lowest mean of above ground dry biomass (5.0 t ha^{-1}) were recorded with control of 0 NPSB kg (Table 5). This result is similar the report conducted that the application rates of NPS fertilizer from 100 to 200 kg ha^{-1} increased biological yield of bread wheat also increased from 16130 to 17129 kg ha^{-1} [2].

viii.Harvest Index

The harvest index of malt barley was highly significantly (p<0.01) affected by NPSB fertilizer rate and varieties while their interaction was non-significant. As the result showed that, the highest harvest index was recorded from the Traveller variety (44.6), while Eboni 174/03 produced the lowest harvest index (33.0) (Table 3). The harvest index is increased with increased application of NPSB fertilizer. As the analysis of variance, the highest mean of harvest index (46.7) was recorded from 150 NPSB kg followed by 200 and 100 NPSB fertilizer rates, while the lowest mean of harvest index (30.5) was recorded from control 0 NPSB kg (Table 3). The result is in line with the study reported that the maximum harvest index (0.50) was obtained when N was applied at 92 kg ha^{-1} [17]. This is also similar to the report conducted that the higher barley harvest index with increased fertilizer rate might be due to higher grain yield per plant at higher fertilizer rates and articulated higher transfer of assimilates to the grain would maximize the harvest index and reduce the proportion of dry matter produced and the maximum harvest index was recorded from plots treated with 250 NPSB kg ha^{-1} blended fertilizers [41],[28] and [12].

Table 3: Effects of NPSB Fertilizer Rates and Variety of Barley on Yield and Morphological Traits

Variety	GY (t ha^{-1})	SY (t ha^{-1})	AGBM (t ha^{-1})	HI
Sabini	3.99^{b}	4.5^{b}	8.5^{b}	40.14^{b}
Eboni174/03	3.7^{b}	4.2^{b}	8.0^{b}	33.4^{c}
Traveller	4.63^{a}	5.2^{a}	9.8^{a}	44.6^{a}
LSD	0.3	0.4	0.6	2.6
NPSB Rate				
0	2.12^{d}	2.9^{d}	5.0^{d}	30.5^{d}
50	3.06^{c}	3.4^{d}	6.5^{c}	34.7^{c}
100	4.13^{b}	4.6^{c}	8.8^{b}	39.8^{b}
150	5.74^{a}	5.8^{b}	11.7^{a}	46.7^{a}
200	5.49^{a}	6.4^{a}	12.0^{a}	45.2^{a}
LSD	0.4	0.5	0.7	6.7
CV	10.2	12.7	9.1	9.0

LSD (0.05) =Least Significant Difference at 5% level's CV=Coefficient of Variation; GY =Grain Yield; SY =Straw Yield; AGBM =Above Ground Biomass; HI=Harvest Index; Means in column followed by the same letters are not significantly different at 5% levels of significance.

B. Quality Parameters

i.Grain Protein Content

The grain protein content of malt barley was highly significantly (p<0.01) affected by NPSB fertilizer rate and varieties while their interaction was non-significant. The maximum grain protein was obtained from Eboni174/03 variety while the lowest grain protein was obtained from the Traveller variety. The grain protein content of malt barley varieties was influenced by NPSB fertilizer rates as shown in (Table 5). Regarding NPSB fertilizer rates the highest grain protein content was recorded from 200 NPSB kg fertilizer rates, while the lowest mean of grain protein contents was recorded from control 0 NPSB kg (Table 4). Therefore, nitrogen rate treatment at an optimum level is required to produce the ultimate quality of protein with optimum grain yield. Genotype and soil condition had strong influences on grain protein concentration at any given N availability, but N supply had the single largest effect on both grain yield and protein concentration [4][43][44][45]. Grain protein contents observed from the Traveller variety were found in a common acceptable value for quality malt production with the application of NPSB fertilizer rate from 0 to 200 kg NPSB ha^{-1} (Table 4). This is agreed with the report that grain yield and protein content in cereal crops generally increased with increasing nitrogen rates [18].

Table 4: Response of Malt Barley Varieties to the Application of NPSB Fertilizer

Variety	PC
Sabini	11.0^{b}
Eboni174/03	11.8^{a}
Traveller	10.9^{b}
LSD	0.3
NPSB Rate	
0	9.6^{d}
50	10.2^{c}
100	11.0^{b}
150	12.5^{a}
200	12.9^{a}
LSD	0.24
CV	3.7

LSD (0.05) =Least Significant Difference at 5% level's CV=Coefficient of Variation; PC =Protein Content; Means in column followed by the same letters are not significantly different at 5% levels of significance.

ii.Hectoliters

The hectoliter weight of malt barley was highly significantly (p<0.01) affected by NPSB fertilizer rate and varieties and their interaction was also significant. The result showed the highest hectoliters (69.133) were recorded from the Traveller variety with 150 kg NPSB ha^{-1}, while the lowest hectoliter was recorded from Eboni 174/03 variety (51.43) with 0 kg NPSB ha^{-1}(Table 5).

The difference among the varieties might be due to differences in genetic make-up and physiological processes of the varieties to forming low or high hectoliter weight and might be a suitable genetic performance of varieties with environmental factors which may lead to an increase the accumulation of carbohydrate in grain to produce heavy grain and as result increased grain weight per spike.

Table 5: The Interaction Response of Malt Barley Varieties to the Application of NPSB Fertilizer

	NPSB (kg-1)				
Variety	0	50	100	150	200
Sabini	53.267^{j}	55.0^{h}	58.3^{ef}	63.733^{bc}	61.633^{d}
Eboni 174/03	51.433^{i}	53.167^{j}	54.067^{ij}	55.933^{d}	57.967^{f}
Traveller	56.533^{g}	59.600^{f}	62.433^{gh}	69.133^{a}	66.000^{b}
LSD(0.05)	1.39				
CV (%)	1.42				

LSD (0.05) =Least Significant Difference at 5% level's CV=Coefficient of Variation; HL =Hectoliter; Means in column followed by the same letters are not significantly different at 5% levels of significance

C. Agronomic Efficiency

The agronomic efficiency of malt barley was highly significantly ($p<0.01$) affected by NPSB fertilizer rates and varieties and their interaction was also significant. As result, agronomic efficiency showed that the highest agronomic efficiency as the ratio of grain to rates of NPSB fertilizers (31.73) was observed in the treatment combination of 50 kg ha^{-1} NPSB fertilizer with Sabini variety, while the lowest agronomic efficiency as the ratio of grain to rates of NPSB fertilizers rates was observed in the treatment combination with 50 kg ha^{-1} NPSB with Eboni 174/03 (10.66) (Table 6). Therefore, the result showed, that the maximum agronomic efficiency at 50 kg ha^{-1} NPSB fertilizers with Sabini variety refers to that crop was get a higher chance to convert nutrients into higher economic yield when there was maximum or optimum nutrient availability in the soil and status of the variety to convert nutrient in to economic yield were different due to their genetic makeup. Results showed that the agronomic efficiency of wheat decreases with increasing N rates and N use efficiency has been shown to vary by crop and among varieties indicating a plant genetic influence on N use efficiency [20].

Table 6: Agronomic Efficiency of Malt Barley as Ratio of Grain Yield to NPSB Fertilizer Rates

	Varieties		
NPSB rate (kg ha^{-1})	**Eboni**	**Sabini**	**Traveller**
50	10.667^{e}	31.73^{a}	13.733^{de}
100	15.433^{de}	25.067^{abc}	18.567^{bcd}
150	18.997^{bcd}	25.643^{ab}	24.09^{bc}
200	10.850^{e}	17.90^{cde}	15.683^{de}
LSD (5%)	7.42		
CV	23.04		

LSD (0.05) =Least Significant Difference at 5% level's CV=Coefficient of Variation; AE =Agronomic Efficiency; Means in column followed by the same letters are not significantly different at 5% levels of significance.

D. Partial Budget Analysis

Partial Budget Analysis of the net benefits, total cost, and Marginal rate of return are listed below in (Table 7). The result of this study indicated that the application of NPSB fertilizer rates and a variety of higher net benefits than the control treatment (Table 7).The partial budget analysis showed that the highest net benefits (184527.0) ETB ha^{-1} with MRR of (439.8%) was recorded at the rate of 150 kg NPSB with Traveller variety followed by 200 kg NPSB fertilizer rates with Traveller variety (177049) ETB ha^{-1}while the lowest net benefits (52596) ETB ha^{-1} was recorded from control fertilizer application with Sabini variety. The minimum acceptable marginal rate of return should be more than 100% [10]. Therefore, the application of 150 kg NPSB with Traveller variety gave the maximum net benefit (184527.0) ETB ha^{-1} with the marginal rate of return (439.8%) was acceptable range (Table 7).

Table 7: Partial Budget Analysis Malt Barley Varieties to the Response NPSB Fertilizer Application

Treatment	**Malt barley (kgha^{-1})**		**Income (ETB ha^{-1})**		**Total Revenue (Birr ha$^{-1)}$**	**TVC (Bir ha^{-1})**	**Net return**	**MRR (%)**
	AGY	ASY	Grain	Straw				
Eboni * 0	1716	2412	51480	7236	58716	0	58716	-----
Eboni *50	2196	2556	65880	7668	73548	2000	71548	1894.2
Eboni *100	3210	3717	96300	11151	107451	3700	103751	2961
Eboni *150	4782	5343	143460	16029	159489	5400	154089	95.7
Eboni *200	4770	5487	143100	16461	159561	7100	152461	D
Sabini * 0	1524	2292	45720	6876	52596	0	52596	---
Sabini * 50	2952	3444	88560	10332	98892	2000	96892	1491.4
Sabini *100	3780	4182	113400	12546	125946	3700	122246	2132
Sabini *150	4986	4770	149580	14310	163890	5400	158490	350.4
Sabini *200	4746	5751	142380	17253	159633	7100	152533	D
Traveller * 0	2496	3321	74880	9963	84843	0	84843	---
Traveller*50	3114	3402	93420	10206	103626	2000	101626	1999.6
Traveller*100	4167	4770	125010	14310	139320	3700	135620	2876.8
Traveller *150	5748	5829	172440	17487	189927	5400	184527	439.8
Traveller *200	5319	8193	159570	24579	184149	7100	177049	D

MRR (%) = Marginal Rate of Return; AGY = Adjusted Grain Yield; ASY = Adjusted Straw Yield; ETB=Ethiopia Birr, Fertilizer application Cost = 300 Birr ha^{-1}; NPSB Cost = 18.00 Birr kg $^{-1}$; Malt barley selling price = 30 Birr kg^{-1}; Straw selling price = 3kg $^{-1}$; TVC =Total Variable Cost; D= Dominated Treatment.

IV. CONCLUSION

In conclusion, malt barley yield in the study area is low because of both biotic and abiotic factors like disease, insects, pests, poor management practices, low soil fertility, soil PH etc. The result revealed that days to 50% heading,90% physiological maturity, plant height, and spike length were highly significantly ($p<0.01$) affected by NPSB fertilizer rates and variety. The number of total tillers, number of effective tillers, thousand grain weight, number of kernels per spike, above ground dry biomass, straw yield, harvest index and grain yield were highly significantly ($p<0.01$) affected by NPSB fertilizer rate and variety. The highest numbers of total tillers per plant, numbers of effective tillers per plant, thousand grain weights, above ground dry biomass, number of kernels per spike, straw yield and harvest index were obtained from 200 kg NPSB fertilizer rates while the highest grain yield was recorded from 150 kg NPSB fertilizer rates. The partial budget analysis shown that application of 150 kg NPSB fertilizer with Traveller variety gave higher net benefits (184527.0) ETB ha^{-1} with MRR of (439.8%), while the lowest net benefits (52596) ETB ha^{-1} was recorded from Sabini variety. Therefore, the application of 150 kg ha^{-1} NPSB fertilizer with Traveller variety in addition to 100 urea ha^{-1} can be tentatively recommended for farmers to produce malt barley in the study area and another area with similar agro-ecological conditions. Since the experiment was conducted for one season at one location, it is suggested that the experiment has to be repeated over a season and multiple locations to make a conclusive recommendation.

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DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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- **Funding Support:** This article has not been sponsored or funded by any organization or agency. The independence of this research is a crucial factor in affirming its impartiality, as it has been conducted without any external sway.
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- **Authors Contributions:** The authorship of this article is contributed equally to all participating individuals.

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